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DESIGN AND ANALYSIS OF RADIATOR BY USING NANO FLUIDS

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ABSTRACT

Radiators are heat exchangers used for cooling and heating purposes to transfer thermal energy from one medium to another. Some radiators were designed to operate in vehicles, homes, and electronics. The radiator is always a source of heat for its environment, as it can either be used to heat this atmosphere or to cool the supply of liquid or coolant. Despite the name, most radiators use convection to transfer the bulk of their heat.

An automotive radiator is a cornerstone of an automotive cooling system that plays a major role in transmitting heat from engine components to the atmosphere through its complex system and operation. It is nothing, but a form of heat exchanger designed to transfer the heat from the warm coolant of the engine to the fan's blown air. The cycles of heat transfer take place from the coolant to the pipes, then through the fins from the tubes to the water. Radiators are used to cool internal combustion engines, especially in vehicles, as well as in piston-engine aircraft, railway locomotives, power generating plants or any related use of such applications. The main function of the automotive radiator is to cool the engine bypassing the coolant through the water jackets of the cylinder. The project's main goal is to design a radiator and analyze radiator CFD using Nanofluid.

Radiator development is performed in the 2014 premium code of solid plays. And, CFD analysis is performed in simulation software for a strong workflow.

KEYWORDS: Radiators, Automobiles, Nanofluids & Cooling System

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Original Article

1. INTRODUCTION

1.1 Automobile

We know that, if internal combustion engines occur, air and fuel ignition will occur inside the engine chamber, and hot gases will be emitted. Gas temperature will be roughly 2300-2500°C. This is an exceptionally high temperature and can result in oil film consumption between the moving parts and the equivalent may be seized or welded. This temperature must be rising along these lines to around 150-200°C, where the engine can generally work skillfully. The excess of cooling is also not appealing, as it decreases the hot capacity. The objective of the cooling framework in this way is to keep the engine running at its most proficient working temperature. It should be noted that when it is cold, the motor is very wasteful and henceforth, the cooling frame is structured to counteract cooling when the motor is heating up and until it reaches the most extremely effective working temperature, at that point it starts cooling.

- About 20-25% of absolute warmth created is utilized for delivering brake control (helpful work).
- The cooling framework is intended to expel 30-35% of all-out warmth.
- Remaining warmth is lost in grinding and diverted by fumes gases.

1.1.1 What Does the Cooling System do for an Engine?

- Despite the fact that gas engines have greatly improved, they are not yet exceptionally capable of transforming the vitality of the substance into mechanical power.
- Most of the gas's vitality (perhaps, 70 percent) is transformed into warmth, and dealing with that heat is the activity of the cooling framework. Indeed, the cooling framework on a vehicle driving down the turnpike spreads enough warmth to warm up two estimated normal houses!
- The cooling framework's essential use is to shield the engine from overheating by moving this warmth to the air, but the cooling framework also has a few other important occupations.
- The engine runs best at a reasonably high temperature in your car.
- Components die faster when the engine is hot, and the engine is less efficient and emanates more pollution.
- Thus, another essential function of the cooling system is to allow the engine to heat up as quickly as possible that might be anticipated under the circumstances and then to maintain the engine at a consistent temperature.

1.2 Cooling System

As the glimmer fittings ignite, the fuel in each chamber is not to drive the vehicle far, an average of 4 chamber vehicles speeding along the expressway at around 50 miles per hour would deliver 4,000 controlled impacts for every minute inside the engine. Obviously, these blasts produce a huge measure of energy and in just minutes, if not managed, will kill a motor. The role of the cooling system is to monitor these high temperatures. The cutting-edge cooling systems in model T have not improved yet, dating back to the' 20s. However, it has turned out to be increasingly reliable and competent in fulfilling its responsibilities, but the basic cooling framework still includes the fluid coolant being passed through the motor, pointing to the radiator to be cooled by the air stream and passing through the vehicle's front flame broil. Regardless of whether the outside air temperature is 1100 Fahrenheit or below zero, the current cooling system must hold the motor at a steady temperature. If the temperature of the motor is too low, the mileage will last and the discharges will rise. The engine will fall to pieces if the temperature is allowed to get unseasonably warm for a really long time.

2. LITERATURE REVIEW

2.1 History of Automobile Radiators

The vehicle advances through water, an integral honeycomb heated pro-Mercedes 35hp vehicle, now arranged by Maybach in 1901. Even today, cruisers start locomotive in the middle of the fluid interior, the stove is connected to a water coat experiences chamber detergents, through which a liquid coolant is siphoned. The radiator transfers the shining fluid from the inside through the outside air, the cold fluid along these lines that is now going this way.

Today’s cars are also facing a situation where current winds start moving at moderate levels; for example, after the facade fires. Now antique vehicles radiator shell is viewed as a union function for manufacturer whereby their marquee/picture is now also filled as a step for their mascot radiator. A wide arrangement on early motor vehicle structure is now reflected in changing radiator conditions. Radiator shells were created from the beginning using metal; otherwise, silver nickel was also an incontrovertible segment above any motor vehicle. Early motor vehicles were regularly

guaranteed with a particularly wealthy driven accompanied by an escort whose consistent orders included cleaning metal radiator. Renault, for example, found a radiator on the back of the vehicle.

2.2 First Generation (1900s-1970s)

Material/Brass100%

Beginning with the introduction of mainly reliable cars through the mid-1970s, Metal often supplied is now 100 percent even for automobiles. Whatever is currently not the proper purpose using light so that nothing can compete with the unique ideal conditions of metal as well.

2.3 Second Generation (1970-1990s)

Aluminum Gains, Copper/Brass Still Leads Market

The state of the radiator improved during the 1970s. Ten years ago, Volkswagen started an air-cooled engine using a water-cooled engine. A few years later, they now wake up to the world oil crisis as well as a reduction in fuel use, notable vehicle manufacturers, now basic calls to deal with vehicles.

With the help of the inherent metal, the material/metal has a 33% thickness around it, even tin manages very little noticeable heat through its various inadequacies. Aluminum is now gradually reasonable in its unrefined state (although not as a radiator strip). These characteristics near basic but covered figures about product analysts that would be difficult to find through copper/metal during the 1980s gave him some new upsurge in energy.

Along these lines, aluminum has outpaced the pack over the years as copper/metal still accounts for 66 percent of normal radiator advertising, despite fresh vehicles of material. Now the copper/metal trade standards of the affiliate are 89%.

3. CLASSIFICATIONS

3.1 Types of Cooling System

There are mainly two types of cooling system:

- Air-cooled system, and
- Water cooled system.

3.1.1 Air Cooling System

Typically, an air-cooled system is used in small motors; say up to 15-20 kW, and in aircraft engines. In this scheme, fins or expanded surfaces are provided on the cylinder walls, cylinder heads, etc. In the engine cylinder, the heat produced by combustion is driven to the fins and heat is transferred to air when the air flows through the fins, depending upon how much heat is transferred to the atmosphere.

- Amount of air flowing through the fins.
- Fin surface area.
- Thermal conductivity of metal used for fins.

3.1.1.1 Advantages of Air Cooled System

- There is no radiator/pump, so the system is light.
- Leakage occurs in the water cooling scheme, but in this system, no leakage occurs.
- There is no need for coolant and antifreeze alternatives.
- This system may be used in cold environments where it may freeze when water is used.

3.1.1.2 Disadvantages of Air Cooled System

- It is less effective in comparison.
- Aircraft and bike motors are used where the motors are immediately subjected to air.

3.1.2 Air Cooling

From the very beginning and ending with a small and typically unrecognized technological switch, cars and trucks were designed over a long period of time using direct air cooling (without an intermediate fluid). Before World War II, water-cooled vehicles and trucks were overheated on a regular basis, as they climbed mountain highways, producing cooling water geysers. This was considered normal, and in the current environment, the most popular mountain highways had car repair shops to overheating engines. ACS (Auto Club Suisse) preserves historic landmarks on the Susten Pass from that era where two radiator refill stations remain. On a cast metal plate, we have directions and can hang a spherical bottom watering next to a water spigot. The sphere's intention was to stop it from being set up and thus to be useless around the building, despite being stolen, as the picture shows. During this time, European companies such as Magirus-Deutz produced air-cooled diesel trucks, Porsche built air-cooled farm tractors and Volkswagen became famous with air-cooled passenger vehicles. In the United States, Franklin designed air-cooled engines. Tatra, based in Czechoslovakia, is known for its large air-cooled V8 car engines, and Tatra engineer Julius Mackerel had released a book. Air-cooled engines are better adapted to environmentally friendly and hot weather, as one can see air-cooled engines start and operate under freezing conditions.

3.2 Components of a Cooling System in the Radiator

- Radiator Cooling Fans
- Pressure Cap
- Reserve Tank Water Pump
- Thermostat
- Bypass System
- Freeze Plugs
- Head Gaskets
- Intake Manifold Gaskets Heater Core
- Hoses

4. WORKING PRINCIPLE

4.1 Basic Principle

Most internal combustion engines operate through an air-cooled heat exchanger (radiator) using either air (a gaseous fluid) or a liquid coolant. At a reasonable temperature, marine engines and certain stationary engines have ready access to a large volume of water. The water can be used directly to cool the engine, but there are often sediments that can block coolant passages or chemicals such as salt that can damage the engine chemically. Therefore, the coolant of the engine will pass through a heat exchanger cooled by the water body. Most liquid-cooled engines use a mixture of water and chemicals such as inhibitors of antifreeze and rust. The anti-freeze mixture industry term is engine coolant. Instead of using a solvent with different properties like propylene glycol or a mixture of propylene glycol and ethylene glycol, some anti-freezes do not use water at all. Most air-cooled engines use some liquid oil cooling to maintain acceptable temperatures for both critical engine components as well as the oil itself. Some air cooling is used by most "liquid-cooled" engines, with the intake stroke of air cooling the combustion chamber. An exception is Winkle engines, where portions of the combustion chamber are never cooled by intake, requiring additional effort to function successfully. Nevertheless, refrigerant properties (water, gas, or air) also influence refrigeration. For example, one gram of oil can absorb about 55 percent of the heat for the same temperature rise (called the specific heat capacity) by comparing water and oil as coolants. Oil has about 90% water content, so only about 50% of the energy of the same volume of water can be consumed by a given volume of oil. Water's thermal conductivity is about four times that of oil, which can help to transfer heat. Oil viscosity may be ten times higher than water, increasing the energy needed to pump oil for cooling, and decreasing the engine's net power output. In comparison with air and water, the air has significantly lower heat capacity per gram and volume (4000) and less than a tenth of conductivity, but also much lower viscosity (about 200 times lower: 17.4 −10Pa•s for air vs. 8.94 −10Pa•s for waters). From the analysis of two paragraphs above, air cooling requires ten times the surface area, hence the fins and air require 2000 times the velocity of flow and thus, circulating air fans require ten times the power of a re-circulating water pump. Moving heat from the cylinder to a large surface area for air cooling may present problems such as difficulties in producing the shapes needed for a good heat transfer and the space required for a large volume of air to flow freely.

4.2 Nano Fluids

A nano liquid is a fluid that comprises particles of nanometer size, known as nano particles. Such liquids are engineered nanoparticle colloidal suspensions in a base liquid. Usually, the nanoparticles used in nano liquids are made from metals, oxides, carbides, and nanotubes of carbon. Air, ethylene glycol and oil are common base fluids. Nanofluids have novel properties that make them potentially useful in many heat transfer applications, including microelectronics, fuel cells, pharmaceutical processes, and hybrid engines, engine cooling/heat control, domestic fridge, refrigerator, heat exchanger, grinding, machining and boiler flue gas temperature. We demonstrate enhanced thermal conductivity and coefficient of convective heat transfer relative to the base fluid.[6] Knowledge of the rheological behavior of nanofluids is found to be very important in evaluating their suitability for convective heat transfer applications. Nanofluids also have special acoustic properties and in ultrasonic fields, it shows the additional shear-wave conversion of a convective heat transfer application. Nanofluids can be assumed to be single-phase fluids in analysis such as Computational Fluid Dynamics (CFD). Nearly, all new academic papers, however, use the concept of two stages. The classical theory of single-phase fluids can be applied where nanofluid's physical properties are taken as a function of both constituent's properties and their concentrations. Nanofluid is modeled by an alternative approach.

5. SOLIDWORKS

Solid Works is a mechanical design automation program that uses the popular graphical user interface of Microsoft Windows.

It is an easy-to-learn tool that allows mechanical designers to sketch ideas easily, experiment with features, dimensions, and create prototypes, detailed drawings.

A Solid Works model consists of parts, assemblies, and drawings.

- Typically, we begin with a sketch, create a base feature, and then add more features to the model. (One can also begin with an imported surface or solid geometry).
- We are free to refine our design by adding, changing, or reordering features.
- Associatively between parts, assemblies, and drawings assures that changes made to one view are automatically reflected in all other views.
- We can generate drawings or assemble it at any time in the design process.
- The Solid Works software lets us customize functionality to suit our needs.
- Software from Solid Works allows us to customize features for meeting our requirements.

Mechanical design automation software Solid Works is a feature-based, parametric solid modeling design tool that benefits from a graphical user interface that is easy to learn from windows. We can create 3-D solid models fully associated with or without using automatic or user-defined relationships to capture design purposes.

Parameters are restrictions whose values determine the model or assembly's shape or geometry. Parameters can be numerical parameters such as line lengths or circle diameters, or geometric parameters such as tangent, parallel, concentration, horizontal or vertical parameters, etc. Numeric parameters can be linked by using relationships that enable them to capture design.

6. MODELING OF RADIATOR

First, draw the rectangle and use the command Boss Extrude.

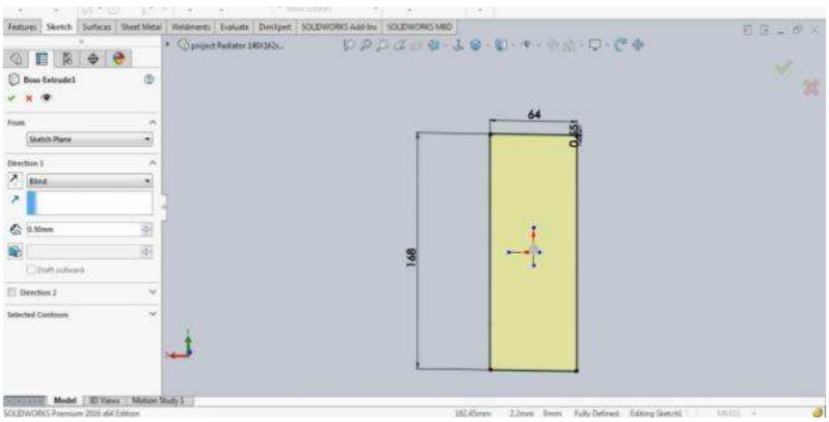

Figure 6.1: Boss Extrude Feature of the Radiator.

And use the Boss extrude on the other side.

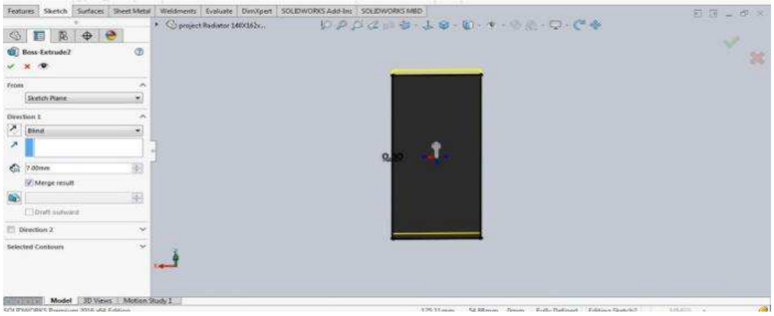

Figure 6.2: Boss Extrude Feature of a Radiator on the Top Side.

Then use the Fillet command corners of the rectangle.

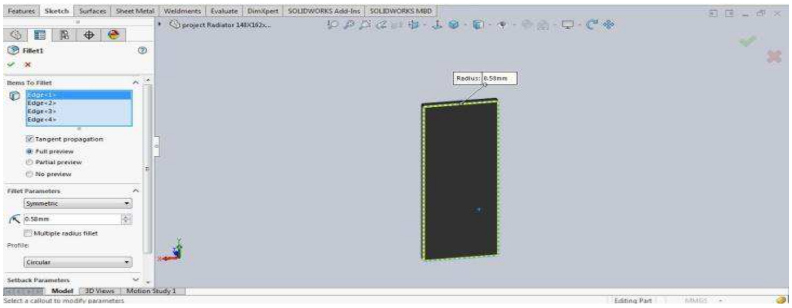

Figure 6.3: Fillet Feature of the Radiator.

And then, use the cut extrudes command on the radiator.

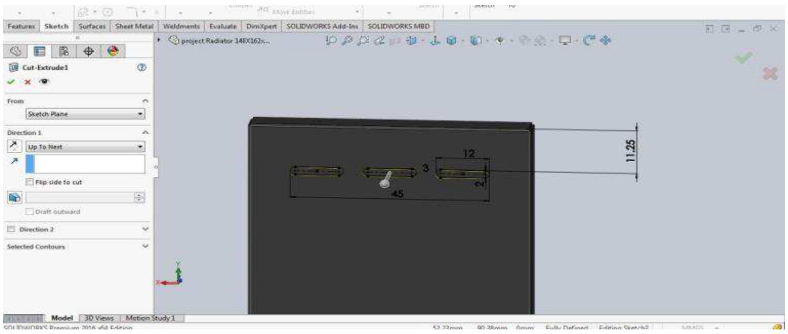

Figure 6.4: Extrude Cut Feature of the Radiator.

And then, the final view of the radiator is shown below.

Figure 6.5: Final View of Radiator.

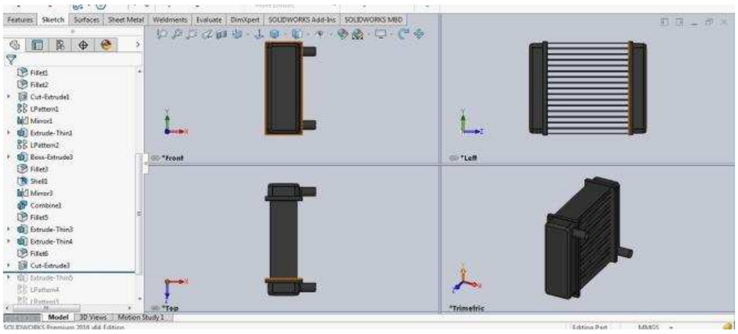

Figure 6.6: Four Side View of the Radiator.

7. SOLID WORKS FLOW SIMULATION

7.1 Solid Works Flow Simulation – An Introduction

Solid Works Flow Simulation 2010 is an add-in package for fluid flow analysis that is available for Solid Works to provide solutions to the full Navier-Stokes equations governing fluid movement. Solid Works Motion and Solid Works Simulation are other packages that can be added to Solid Works. An analysis of fluid flow using Flow Simulation involves a number of basic steps shown in the figure below.

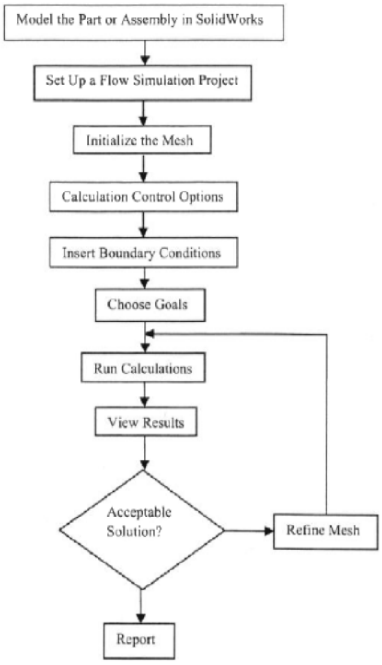

Figure 7.1: Flowchart for Fluid Flow Analysis using Solid Works Flow Simulation.

8. CFD ANALYSIS OF RADIATOR

8.1 Water

Water is used as a fluid in the radiator for the general setting of CFD analysis.

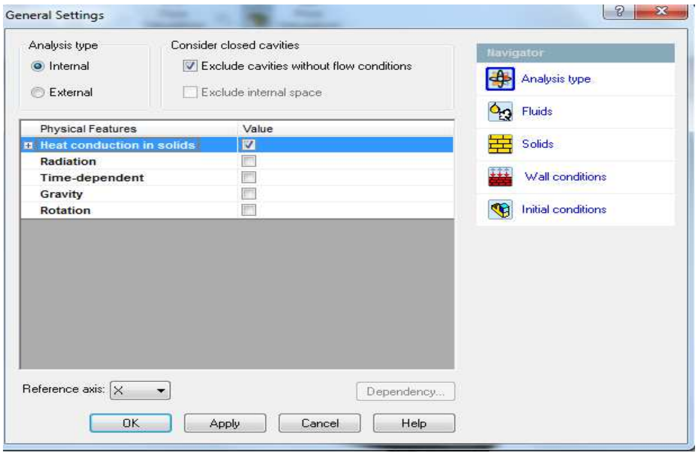

Figure 8.1: General Settings of CFD Analysis of Water.

Water as fluid selected as the default fluid settings.

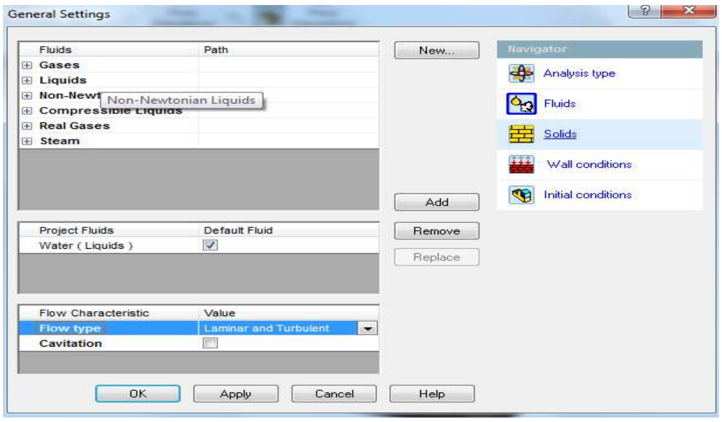

Figure 8.2: Selecting the Water as Default Fluid.

8.1.1 Results also Counter

Temperature counters are generated in the radiator from the front side of the design.

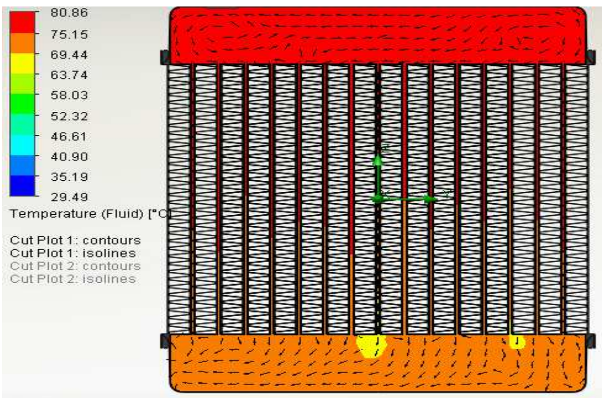

Figure 8.3: Temperature Counters on the Front Side of Design.

Temperature counters are generated in the radiator from the side view of the design.

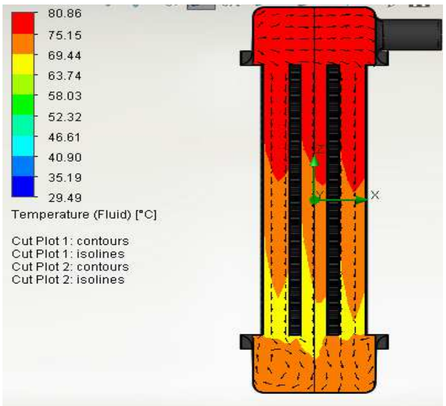

Figure 8.4: Temperature Counters of the Side View of the Design.

8.1.2 Pressure

Pressure counters are generated in the radiator from the front side of the design and side view of design.

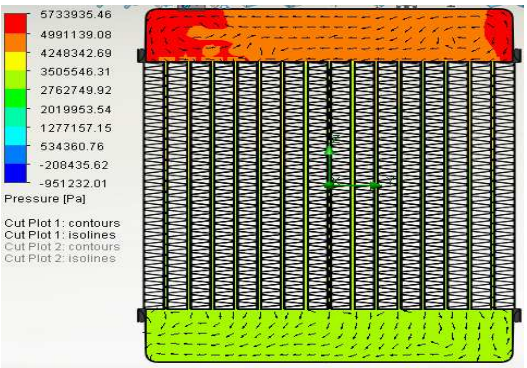

Figure 8.5: Pressure Counters of the Front Side of the Design.

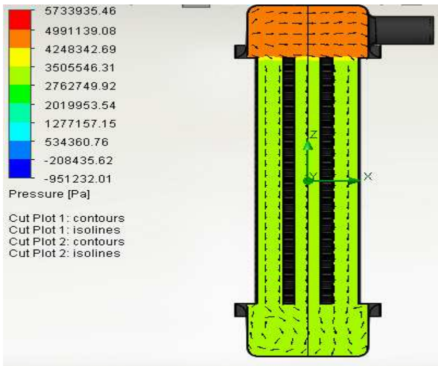

Figure 8.6: Pressure Counters of the Side View of the Design.

8.1.3 Velocity

Velocity counters are generated in the radiator from the front side of the design.

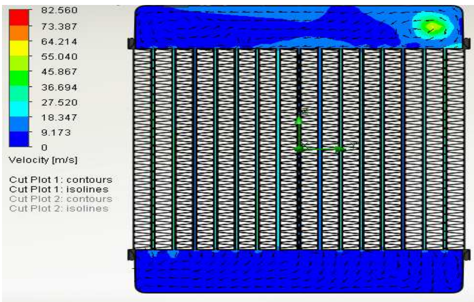

Figure 8.7: Velocity Counters on the Front Side of the Design.

Velocity counters are generated in the radiator from the side view of the design.

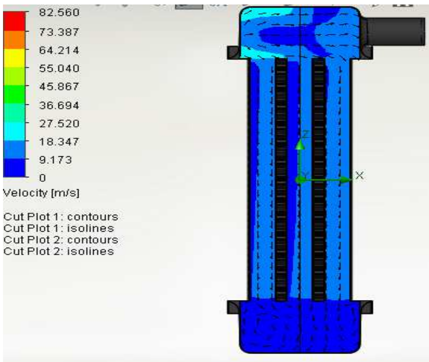

Figure 8.8: Velocity Counters of the Side View of the Design.

8.2 Titanium Oxide (TiO_2)

Selecting Titanium oxide is used as a fluid in the radiator for the general setting of CFD analysis**.**

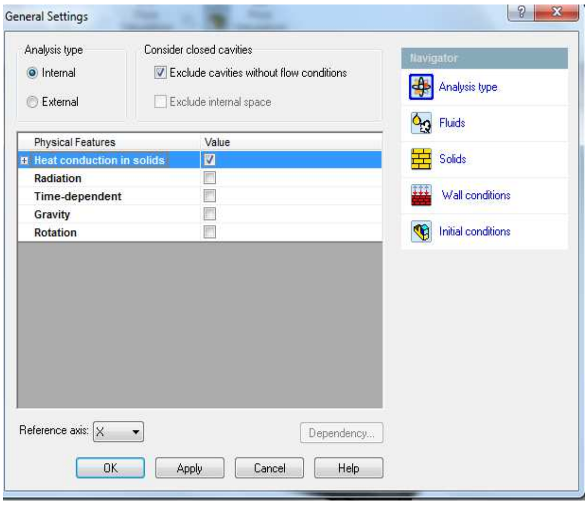

Figure 8.9: General Settings of CFD Analysis of Titanium Oxide.

8.2.1 Results also Counter

Temperature counters are generated in the radiator from the front side of the design.

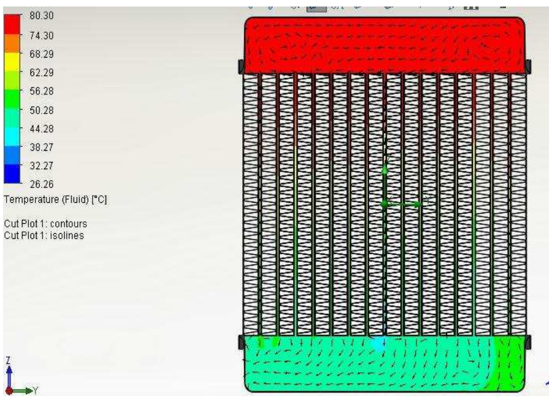

Figure 8.10: Temperature Counters of the Front Side of Design.

Temperature counters are generated in the radiator from the side view of the design.

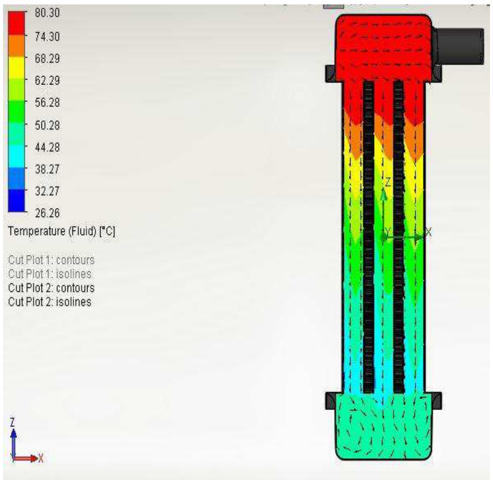

Figure 8.11: Temperature Counters of the Side View of Design.

8.2.2 Pressure

Pressure counters are generated in the radiator from the front side of the design**.**

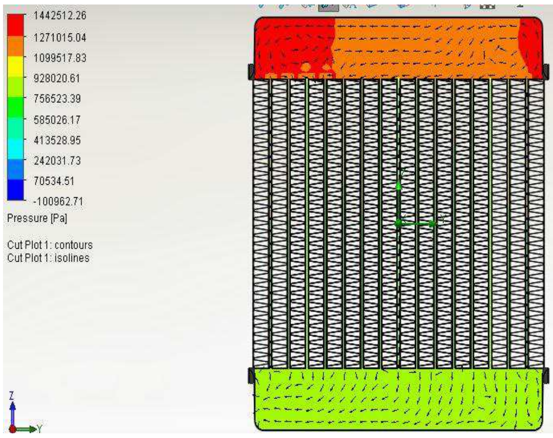

Figure 8.12: Pressure Counters of the Front Side of Design.

Pressure counters are generated in the radiator from the side view of the design.

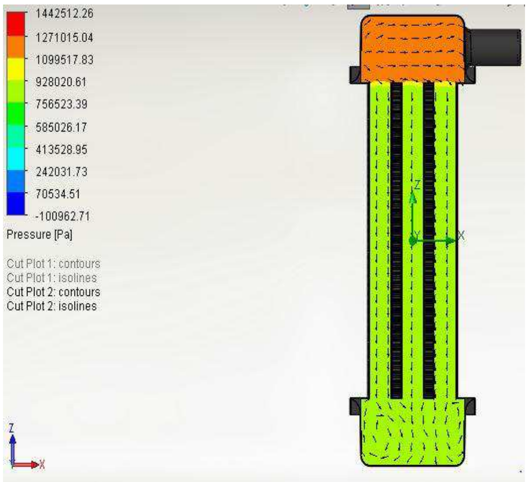

Figure 8.13: Pressure Counters from a Side View of Design.

Velocity

Velocity counters are generated in the radiator from the front side of the design.

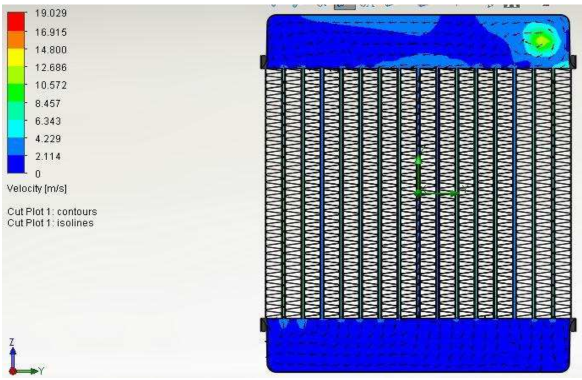

Figure 8.14: Velocity Counters of the Front Side of Design.

Velocity counters are generated in the radiator from the side view of the design.

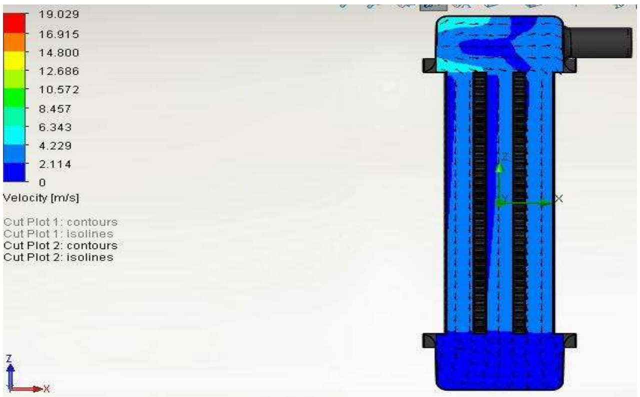

Figure 8.15: Velocity Counters from a Side View of Design.

8.3 Aluminum Oxide (Al_2O_3)

Selecting Aluminum oxide is used as a fluid in the radiator, for the general setting of CFD analysis.

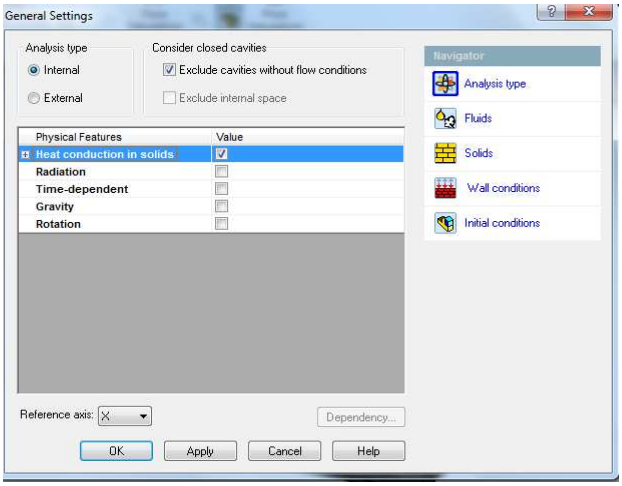

Figure 8.16: General Settings of CFD Analysis about Aluminum Oxide.

8.3.1 Results also Counter

8.3.1.1 Temperature

Temperature counters are generated in the radiator from the front side of the design.

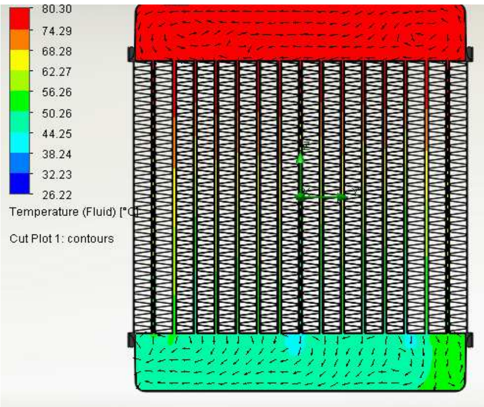

Figure 8.17: Temperature Counters on the Front Side of Design.

Temperature counters are generated in the radiator from the side view of the design.

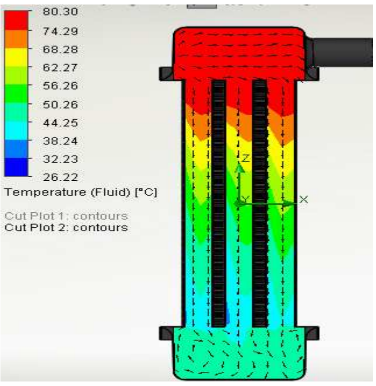

Figure 8.18: Temperature Counters from a Side View of Design.

8.3.2 Pressure

Pressure counters are generated in the radiator from the front side of the design.

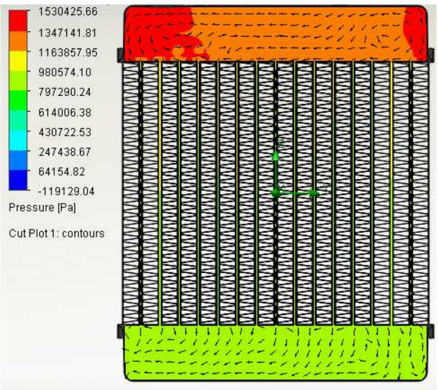

Figure 8.19: Pressure Counters of the Front Side View of Design.

Pressure counters are generated in the radiator from the side view of the design.

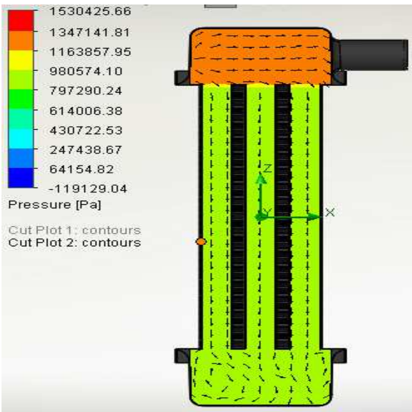

Figure 8.20: Pressure Counters of the Side View of Design.

8.3.3 Velocity

Velocity counters are generated in the radiator from the front side of the design.

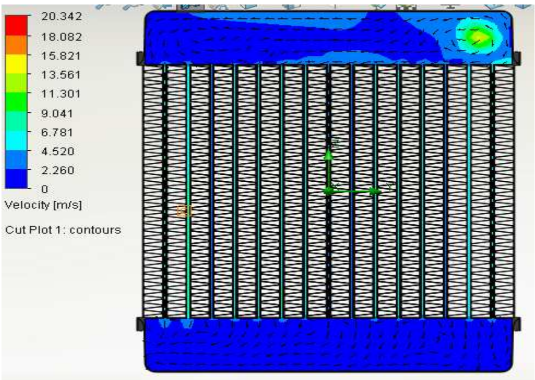

Figure 8.21: Velocity Counters of the Front Side of Design.

Velocity counters are generated in the radiator from the side view of the design.

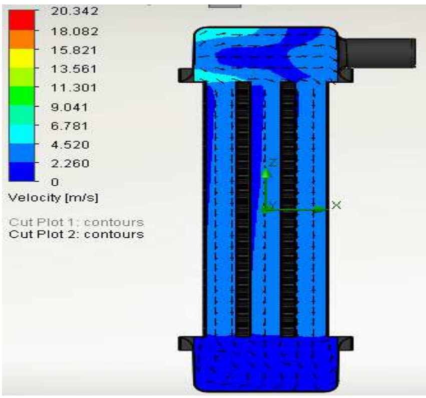

Figure 8.22: Velocity Counters of the Side View of Design.

9. RESULTS

9.1 Results Table

9.1.1 For Water

From the table, we have noted the values of the temperature, pressure, and velocity of the water.

Table 9.1: Results of the Water

Name	Current Value	Progress	Criterion	Averaged Value	Minimum Value	Maximum Value
GG Av Temperature (Fluid) 1	75.8513 °C	Achieved (IT = 131)	1.67276 °C	75.8525 °C	75.8505 °C	75.8543 °C
GG Av Temperature (Solid) 1	48.5009 °C	Achieved (IT = 130)	0.767722 °C	48.4989 °C	48.4956 °C	48.5039 °C
GG Av Total Pressure 1	4.09271e+006 Pa	Achieved (IT = 123)	27591.9 Pa	4.10185e+006 Pa	4.09256e+006 Pa	4.10548e+006 Pa
GG Av Velocity 1	10.6688 m/s	Achieved (IT = 134)	0.130364 m/:	10.8132 m/s	10.6688 m/s	10.8819 m/s
GG Bulk Av Temperature (Fluid)	75.8397 °C	Achieved (IT = 131)	1.67243 °C	75.8408 °C	75.8388 °C	75.8426 °C
GG Bulk Av Total Pressure 1	4.09049e+006 Pa	Achieved (IT = 124)	27520.8 Pa	4.09962e+006 Pa	4.09034e+006 Pa	4.10324e+006 Pa
GG Bulk Av Velocity 1	10.6609 m/s	Achieved (IT = 133)	0.129986 m/:	10.8049 m/s	10.6609 m/s	10.8734 m/s
GG Mass Flow Rate 1	-5.8625e-005 kg/s	Achieved (IT = 116)	1.05059 kg/s	-1.03105e-005 kg/s	-0.000228191 kg/s	0.000241798 kg/s
GG Max Temperature (Fluid) 1	80.86 °C	Achieved (IT = 151)	0.0259624 °C	80.863 °C	80.86 °C	80.8649 °C
GG Max Total Pressure 1	7.00082e+006 Pa	Achieved (IT = 140)	53933.6 Pa	7.02305e+006 Pa	6.98415e+006 Pa	7.04385e+006 Pa
GG Max Velocity 1	82.1049 m/s	Achieved (IT = 131)	0.416748 m/:	82.2791 m/s	82.1049 m/s	82.3959 m/s
GG Min Temperature (Fluid) 1	29.4868 °C	Achieved (IT = 172)	0.339449 °C	29.9023 °C	29.4868 °C	30.546 °C
GG Min Total Pressure 1	-951232 Pa	Achieved (IT = 116)	65548.6 Pa	-946752 Pa	-951562 Pa	-943237 Pa
GG Min Velocity 1	0 m/s	Achieved (IT = 116)	0 m/s	0 m/s	0 m/s	0 m/s

9.1.2 For Tio_2

From the table, we have noted the values of the temperature, pressure, and velocity of the Tio_2.

Table 9.2: Results of the TiO_2

Name	Current Value	Progress	Criterion	Averaged Value	Minimum Value	Maximum Value
GG Av Temperature (Fluid) 1	64.2501 °C	Achieved (IT = 127)	1.32452 °C	64.2421 °C	64.235 °C	64.2505 °C
GG Av Temperature (Solid) 1	41.7761 °C	Achieved (IT = 127)	0.568101 °C	41.7714 °C	41.7673 °C	41.7761 °C
GG Av Total Pressure 1	1.06272e+006 Pa	Achieved (IT = 116)	5950.87 Pa	1.06276e+006 Pa	1.06206e+006 Pa	1.06368e+006 Pa
GG Av Velocity 1	2.44831 m/s	Achieved (IT = 140)	0.0284276 m/:	2.47114 m/s	2.44831 m/s	2.47925 m/s
GG Bulk Av Temperature (Fluid)	64.2501 °C	Achieved (IT = 127)	1.32452 °C	64.2421 °C	64.235 °C	64.2505 °C
GG Bulk Av Total Pressure 1	1.06272e+006 Pa	Achieved (IT = 116)	5950.87 Pa	1.06276e+006 Pa	1.06206e+006 Pa	1.06368e+006 Pa
GG Bulk Av Velocity 1	2.44831 m/s	Achieved (IT = 140)	0.0284276 m/:	2.47114 m/s	2.44831 m/s	2.47925 m/s
GG Mass Flow Rate 1	-5.28326e-005 kg/s	Achieved (IT = 116)	1.05059 kg/s	2.31939e-005 kg/s	-0.000200894 kg/s	0.00027932 kg/s
GG Max Temperature (Fluid) 1	80.3036 °C	Achieved (IT = 149)	0.0091845 °C	80.3031 °C	80.302 °C	80.3045 °C
GG Max Total Pressure 1	1.73312e+006 Pa	Achieved (IT = 135)	12323.1 Pa	1.73662e+006 Pa	1.72879e+006 Pa	1.74317e+006 Pa
GG Max Velocity 1	18.9138 m/s	Achieved (IT = 116)	0.0859942 m/:	18.9189 m/s	18.8861 m/s	18.9415 m/s
GG Min Temperature (Fluid) 1	26.266 °C	Achieved (IT = 166)	0.204596 °C	26.3559 °C	26.266 °C	26.4465 °C
GG Min Total Pressure 1	-100968 Pa	Achieved (IT = 116)	14637.7 Pa	-101279 Pa	-102943 Pa	-100081 Pa
GG Min Velocity 1	0 m/s	Achieved (IT = 116)	0 m/s	0 m/s	0 m/s	0 m/s

9.1.3 For Al_2O_3

From the table, we have noted the values of the temperature, pressure, and velocity of the Al_2O_3

Table 9.3: Results of Al_2O_3

Name	Current Value	Progress	Criterion	Averaged Value	Minimum Value	Maximum Value
GG Av Temperature (Fluid) 1	63.9927 °C	Achieved (IT = 127)	1.31773 °C	64.0042 °C	63.99 °C	64.0163 °C
GG Av Temperature (Solid) 1	42.4441 °C	Achieved (IT = 127)	0.591236 °C	42.4494 °C	42.4433 °C	42.4565 °C
GG Av Total Pressure 1	1.12485e+006 Pa	Achieved (IT = 116)	6400.6 Pa	1.12616e+006 Pa	1.12435e+006 Pa	1.12779e+006 Pa
GG Av Velocity 1	2.59196 m/s	Achieved (IT = 138)	0.0306776 m,	2.61503 m/s	2.59132 m/s	2.64053 m/s
GG Bulk Av Temperature (Fluid)	63.9927 °C	Achieved (IT = 127)	1.31773 °C	64.0042 °C	63.99 °C	64.0163 °C
GG Bulk Av Total Pressure 1	1.12485e+006 Pa	Achieved (IT = 116)	6400.6 Pa	1.12616e+006 Pa	1.12435e+006 Pa	1.12779e+006 Pa
GG Bulk Av Velocity 1	2.59196 m/s	Achieved (IT = 138)	0.0306776 m,	2.61503 m/s	2.59132 m/s	2.64053 m/s
GG Mass Flow Rate 1	0.000163562 kg/s	Achieved (IT = 116)	1.05059 kg/s	-4.15654e-006 kg/s	-0.000181231 kg/s	0.000196878 kg/s
GG Max Temperature (Fluid) 1	80.2957 °C	Achieved (IT = 150)	0.00905201 °	80.2974 °C	80.2955 °C	80.2991 °C
GG Max Total Pressure 1	1.84581e+006 Pa	Achieved (IT = 116)	13190.7 Pa	1.84604e+006 Pa	1.83864e+006 Pa	1.85679e+006 Pa
GG Max Velocity 1	20.2436 m/s	Achieved (IT = 135)	0.0943386 m,	20.2454 m/s	20.2168 m/s	20.2795 m/s
GG Min Temperature (Fluid) 1	26.224 °C	Achieved (IT = 209)	0.216211 °C	26.2558 °C	26.1125 °C	26.332 °C
GG Min Total Pressure 1	-119129 Pa	Achieved (IT = 116)	15690.4 Pa	-118673 Pa	-119598 Pa	-117961 Pa
GG Min Velocity 1	0 m/s	Achieved (IT = 116)	0 m/s	0 m/s	0 m/s	0 m/s

From the table, inlet temperature and outlet temperature values are noted down.

Table 9.4: Results Table

Fluid	Inlet temperature (^{0}C)	Outlet temperature(^{0}C)
Water	80	29.49
TIO2	80	26.26
AL2O3	80	26.22

10. CONCLUSIONS

The internal combustion engine cooling system's efficiency depends primarily on its unit performance. The radiator is the central component in this system. In this project, brief studies are carried out on radiators, types, and work on Nanofluid studies, applications are being made. Radiator modeling is done using software for Solid Works 2016. Flow simulation module CFD research is performed on the radiator using strong plays. Three different liquids, namely common fluid water and two, nanofluids that is titanium oxide (TiO_2) and aluminum (Al_2O_3), by selecting radiators. Boundary conditions are provided as 800c for fluid inlet temperature, which is cooled at 250c ambient temperature by radiator pipe and fins through the convection process. After analysis, temperature, velocity, and fluid pressure are noted and tabulated due to the convection temperature of the fluid flow inside the radiator. We can conclude from the result table that nanofluids give better convection, i.e. gives better cooling compared to water for the engine. Compared to all the fluids used for analysis, Aluminum Oxide (Al_2O_3) yields the best results.

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